

VERSION WITH MARKINGS TO SHOW CHANGES MADE (CLAIMS)

[Claims]

CLAIMS

1. (amended) An electronic circuit [(1, 3)] for controlling a gas discharge lamp [(4)], comprising [generation] means for generating a high frequency pulse train [that may be] for being applied to the electrodes of the lamp to light the lamp, [(4)], means [by which the generation means may be connected] for connecting the means for generating a high frequency pulse train to an electrical power source, and a choke [(L3)] to limit the current drawn by the lamp [(4)], [characterized] characterized in that the circuit comprises means [(3)] for producing a first series of pulses [(P0)] and [independent from this] means for producing a second series of pulses [(P1)] independently from the first series of pulses, and means [(T0, T1, L3)] for combining additively the first and second series of pulses to produce the high frequency pulse train.

2. (amended) [An] The electronic circuit [(1, 3)] as claimed in Claim of claim 1, [in which] wherein the means [(T0, T1, L3)] for combining additively the first and second series of pulses includes the choke [(L3)] which connects together the first and second series of the pulses [(P0, P1)].

3. (amended) [An] The electronic circuit [(1, 3)] as claimed in] of claim [1] 2, [in which] wherein the circuit [(1, 3)] has paired outputs [(TP10, TP20, TP11, TP21)] each pair of which provides a steady low voltage output [which may be] for being applied to heated electrodes of the lamp [(4)].

4. (amended) [An] The electronic circuit [(1, 3)] as claimed in] of claim [1] 3, [in which] wherein the means for combining the first and second series of pulses [(P0, P1)]

includes an isolating transformer [means(T0, T1)] to electrically isolate the lamp [(4)] from the power source.

5. (amended) [An] The electronic circuit [(1, 3)as claimed in] of claim [1] 4, [in which] wherein the means [(T0, T1, L3)] for combining the first and second series of pulses [(P0, P1)] comprises a first transformer [(T0)] and a second transformer [(T1)], the primaries of each transformer receiving respectively the first and second series of pulses [(P0, P1)], each of the secondaries having a tap [(TP30, TP31) which may be] for being electrically connected to the contacts of the lamp [(4)] and each having another tap [(TP40, TP41)] electrically connected to the choke [(L3)] so that the choke combines the secondaries and the choke [(L3)] in series between the contacts.

6. (amended) [An] The electronic circuit [(1, 3)as claimed in] of claim 5, [in which] wherein at least one of the transformers [(T0, T1)] has a secondary with a pair of taps [(TP10, TP20, TP11, TP21)that may be] for being electrically connected to heater elements of the lamp [(4)].

7. (amended) [An] The electronic circuit [(1, 3)as claimed in] of claim 6, [in which] wherein one of the secondary taps [(TP20, TP21)] for the heater element is electrically connected to one of the secondary taps [(TP30, TP31)] for the lamp contacts.

8. (amended) [An] The electronic circuit [(1, 3) for controlling a gas discharge lamp (4) as claimed in] of claim 1, further comprising means [(1)] for shifting the phase of the first series of pulses relative to the second series of pulses, the means [(T0, T1, L3)] for combining the first and second series of pulses [(P0, P1)] thereby varying the width of pulses in the pulse train.

9. (amended) [An] The electronic circuit [(1, 3) as claimed in] of claim 8, further comprising means [to detect] for detecting a variation in a supply voltage from the power source, the means for shifting the phase of the first series of pulses relative to the second series of pulses responding to a variation in the supply voltage so that the lamp [(4)] output [may] will be held steady as the supply voltage varies.

10. (amended) [An] The electronic circuit [(1, 3) for controlling a gas discharge lamp (4) as claimed] of claim [8] 9, further comprising light level control means for setting a desired intensity of light output from the lamp [(4)], the means [(1)] for shifting the phase of the first series of pulses [(P0)] relative to the second series of pulses [(P1)] responding to the light level control means so that the lamp [(4)] output [may] will be set at a desired level as the width of the pulses is varied.

11. (amended) [An] The electronic circuit [(1, 3) as claimed in] of claim 10, further comprising motion detection means [to detect] for detecting motion of an object in the vicinity of the circuit, the light level control means responding to the motion detection means so that the lamp [(4)] output [may] will be set at a desired level according to the detected motion as the width of the pulses is varied.

12. (amended) [An] The electronic circuit [(1, 3) as claimed in] of claim 1, in which the pulse train comprises pulses of both positive and negative polarity.

13. (amended) [A] The electronic circuit of claim 1, further comprising a light fitting having contacts for [a] the gas discharge lamp [(4) and an electronic circuit (1, 3) as claimed in claim 1].

**VERSION OF SPECIFICATION PAGES WITH MARKINGS TO
SHOW CHANGES MADE**

[Gas Discharge Lamp Drive Circuitry]
GAS DISCHARGE LAMP DRIVE CIRCUITRY PROVIDING INDEPENDENT
PULSE SERIES

BACKGROUND

a. Field of the Invention

The present invention relates to an apparatus and method for driving a gas discharge lamp, and in particular for dimmably or non-dimmably driving fluorescent lamps or tubes.

b. Related Art

Fluorescent lamps are tubes that are widely used in the home, office and in industry to provide lighting. Such lamps generally consist of a tubular glass envelope, up to 2.44 m (8 feet) long, filled with an inert gas such as krypton or argon which when electrically excited in a gas discharge irradiates a fluorescent coating, such as a powder comprising a (Tb, Ce, Gd, Mg) borate, a (Eu, Ba, Mg) aluminate and a (Y, Eu) oxide, on the inside of the glass. An example of such a tube, 1.22 m (4 feet) long, is the model `TL'D 36 Watt sold under the trade names ``Super 80 (/840) New Generation'' and ``Standard (/33)'' by Philips Electronic and Associated Industries Limited.

All gas discharge lamps, including fluorescent lamps, require a ballast to operate. The ballast provides a high initial voltage to initiate the discharge, then rapidly limits the lamp current to safely sustain the discharge. Ballasts are manufactured for three main classes of fluorescent lamp: preheat, rapid start and instant start.

Preheat operation lamp electrodes are heated prior to initiating the discharge. A starter switch closes, permitting a current to flow through each electrode. The starter switch rapidly cools down, opening the switch, and triggering the supply voltage across the arc tube,

initiating the discharge. No auxiliary power is applied across the electrodes during operation.

Rapid start operation lamp electrodes are heated prior to

amount of harmonic distortion produced by high frequency ballasts.

It is an object of the invention to provide a circuit for a high frequency ballast for a gas discharge lamp that addresses these problems and which may be dimmable, and which may be used with certain types of gas discharge lamp such as high output 2.44 m fluorescent lamps which to date have not benefited from the increased efficiencies possible with high frequency operation.

SUMMARY OF THE INVENTION

According to the invention, there is provided an electronic circuit for controlling a gas discharge lamp, comprising generation means for generating a high frequency pulse train that may be applied to the electrodes of the lamp to light the lamp, means by which the generation] for connecting the means [may be connected] for generating a high frequency pulse train to an electrical power source, and a choke to limit the current drawn by the lamp, characterized in that the circuit comprises means for producing a first series of pulses and [independent from this] means for producing a second series of pulses independently from the first series of pulses, and means for combining additively the first and second series of pulses to produce the high frequency pulse train.

In a preferred embodiment of the invention, the circuit is for a fluorescent lamp.

The term high frequency is intended to exclude frequencies above those used for mains supply, i.e. above 50 to 60 Hz. The value of the high frequency may depend on a number of factors, in particular the type of lamp and the physical size and power rating of the lamp.

The arrangement is such that the rms power level of the high frequency pulse train is determined by the first and

second series of pulses, and in particular because the series of pulses are independent of each other may be set Preferably, this power level should be substantially constant and, in the case of the circuit for dimmably controlling the lamp, unaffected by the phase shifting of the first and second series of pulses with respect to one another.

The modulation means may vary the width of each pulse in the pulse train similarly, that is, so that the ratio of on/off time for each combined high frequency pulse is substantially the same.

It would, however, alternatively be possible to vary the width of each combined high frequency pulse in the pulse train dissimilarly, that is, so that the ratio of on/off time for at least some of the adjacent pulses in the pulse train are not substantially the same, so long as the gaps between pulses do not become so long that the pulse train becomes substantially discontinuous, so causing the tube to flicker off at lower average duty cycles.

The pulse train may comprise pulses of just one polarity, but preferably comprises pulses of both positive and negative polarity.

Circuitry such as that described above is not bulky and may readily be incorporated in a light fitting having contacts for a gas discharge lamp. Alternatively, the circuit may be separate from the light fitting, although it would be necessary to provide appropriate transmission lines, e.g. coaxial cable, and shielding to prevent stray leakage of electromagnetic radiation.

The invention will [now] be further described by way of example to the accompanying drawings[, in which].

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic diagram of a circuit for dimmably controlling a fluorescent lamp according to the invention, having a micro-controller which controls an inverter circuit connected to the lamp;

Figure 2 is a diagram of a pair of wave forms generated by the inverter circuit of Figure 1;

Figure 3 is a circuit diagram of the micro-controller of Figure 1;

Figure 4 is a circuit diagram of the inverter of Figure 1 connected to the lamp;

Figure 5 is a schematic diagram of the output from the inverter across the fluorescent lamp;

Figure 6A to 6L are photographs of oscilloscope traces showing voltages representative of the current supplied by the inverter to the fluorescent lamp, as measure using a feedback winding on the choke; and

Figures 7A to 7I are photographs of oscilloscope traces showing the voltage supplied by the inverter to the fluorescent lamp, as measured across the lamp.

DETAILED DESCRIPTION

Referring first to Figures 1 and 2, a micro-controller 1 is connected to mains electrical power and a dimmer switch 2. The micro-controller has standard circuitry for mains rectification and stabilization (not shown), and supplies an inverter circuit 3 with dc power at 320 V, in addition to low voltage dc supply V_{cc} at 5 V and three independent supplies V_{DD1} , V_{DD2} and V_{DD3} at 15 V. The inverter circuit 3 is of the rapid start type.

[Abstract] ABSTRACT

[Gas Discharge Lamp Drive Circuitry]

[The present invention relates to a]An apparatus and method for driving a gas discharge lamp, and in particular for dimming fluorescent lamps or tubes. An electronic circuit for controlling a gas discharge lamp is connected to an electrical power source and [(4) comprises generation means for] generat[ing]es a high frequency pulse train that [may be] is applied to the electrodes of the lamp [(4)] to light the lamp. [means by which the generation means may be connected to an electrical power source,] [a]A choke [(L3) to] limits the current drawn by the lamp. [(4), means (3) for producing a]A first [(P1)]series of pulses is produced and [independent from this] a second [(P1)] series of pulses is produced independently from the first, [and means (T1, T1, L3) for combining additively] the first and second series of pulses being combined additively to produce the high frequency pulse train.

REMARKS

The Office Action included several objections to the specification and claims, rejections of the claims under 35 USC §112, and rejections of the claims under 35 USC §102. Each of the objections and rejections will be responded to under the corresponding subheading below.

a. Response to Objections to Specification

The specification was objected to as lacking section headings. By the present amendment, Applicant has corrected the specification to include appropriate section headings.

The abstract was objected to as including legal phraseology and a reference to "Figure 4". By the present amendment, the abstract of Page 27 has been corrected to remove legal phraseology, such as "means" and "said". The reference to "Figure 4" has also been removed.

The title was objected to as not being descriptive. By the present amendment, the title has been amended to read "Gas Discharge Lamp Drive Circuitry Providing Independent Pulse Series". It is respectfully submitted that the new title is clearly indicative of the invention to which the claims are directed.

The Summary of the Invention section has also been amended to reflect amendments made to the main claim in the application.

b. Response to Objections to Claims

Claims 1-13 were objected to because of a variety of informalities.

The informalities identified in the Office Action have generally been corrected as suggested by the Examiner. However, the term --a-- has not been inserted before the phrase "means for" where this appears in the claims. It is believed that the construction "means for..." is acceptable means-plus-function language under 35 USC §112, without the inclusion of the term "a". However, if the Examiner believes that "a" should be included in these phrases, Applicant will be pleased to make additional amendments.

c. Response to §112 Rejections

Claims 1-13 were rejected as indefinite, on a number of grounds. Each of these will be addressed below.

At claim 1, line 5, the phrase "means by which the generation means may be connected" has been amended to read "means for connecting the means for generating", so as to clarify what is meant thereby.

At claim 1, line 9, the phrase "independent from this a second series" has been amended to read "means for producing a second series of pulses independently from the first series of pulses", so as to clarify what is meant thereby; as suggested, the word "this" has been deleted.

At claim 1, lines 3 and 5, the term "may be" has been amended to read "for being" so as to make it clear that the limitation is required.

At claim 1, line 12, the term "the high-frequency pulse train" finds antecedent basis at claim 1, line 3.

At claim 2, line 2, the term "means for combining the first and second series of pulses" has been amended to read "means for combining additively the first and second series of pulses", so as to make it clear that this refers back to last element in claim 1.

At claim 3, line 4, the term "may be" has been amended to read "for being" so as to make it clear that the limitation is required. The same amendment has been made at claim 5, line 7, and claim 6, line 4.

At claim 6, line 4, the term "heater elements" has not been amended; this term refers to the heater elements which are an internal part of a conventional fluorescent tube or similar gas discharge lamp. Although interconnected, the heater elements are a convention considered different from the electrodes and contacts *per se*. This same explanation pertains to the term "heater element" at claim 7, line 2.

At claim 9, line 6, the term "may be" has been amended to read "will be" so as to make it clear that the limitation is required. The same amendment has been made at claim 11, line 5.

Claims 2-13 were considered vague and indefinite on virtue of their dependency on claim 1. The dependency of claims 3-5 and claim 10 have been revised by the present amendment, which in turn revises the dependency of the claims that depend from the amended claims. It is respectfully submitted that the revised dependencies render the claims satisfactorily definite.

Other amendments have been made to delete reference numerals and otherwise improve the form of the claims.

It will be understood that the foregoing amendments clarify the claims but do not affect the patentability of the subject matter set forth therein.

d. Response to §102 Rejections

Claims 1-8, 12 and 13 were rejected under 35 USC §102(b) as being anticipated by Lester (U.S. 4,998, 046). For the reasons explained below, Applicant respectfully traverses this rejection.

In order to anticipate a claim, a reference must teach every element of the claim (MPEP 2131). Applicant's independent claim 1 includes elements (clarified by the present amendment) which expressly requires (a) "means for producing a first series of pulses", and (b) "means for producing a second series of pulses independently from the first series of pulses (emphasis added)". Claims 7-8 and 12-13 depend from claim 1, and therefore include the same limitations. As is explained in Applicant's specification, the present invention thus provides two separate pulse generators that can generate a series of pulses with any arbitrary phase difference, which provides a number of important benefits for controlling the output of a gas discharge lamp.

Lester does not show "means for producing a second series of pulses independently from the first series of pulses" as required by Applicant's claims. To the contrary, Lester teaches a circuit in which two series of pulses are provided through drivers (78, 80) in such a way that the two series of pulses in Lester are always 180 degrees apart (e.g., see Column 7, lines 4-12). The series of pulses are therefore dependent on one another, which is the opposite of what is required by Applicant's claims.

Accordingly, since Lester does not show every element of claim 1 and its dependent claims, Lester does not anticipate the claims. Applicant therefore respectfully requests that the rejection of the claims under 35 USC §102 be reconsidered and withdrawn.

Furthermore, being that the reference provides no motivation for producing the second series of pulses independently from the first, and because to do so would be contrary to the express teachings of the reference, it would not be obvious to modify Lester to meet the

requirements of Applicant's claims. Applicant therefore respectfully submits that all pending claims are patentably distinct over the cited reference.

e. Allowable Subject Matter

Claims 9-11 were stated to be allowable if rewritten to overcome the rejections under 35 USC §112 and to include all of the limitations of the base claim and any intervening claims.

Accordingly, new claims 14-16 correspond to claims 9-11 rewritten to overcome the rejections under 35 USC §112 and to include all of the limitations of the base claim and intervening claims. It is therefore believed that new claims 14-16 are in condition for allowance.

f. Missing Information Disclosure Statement

The Information Disclosure Statement dated 17 April 2001 was indicated to be missing. The Examiner stated that only the IDS dated 14 February 2001 has been considered.

Accordingly, Applicant submits herewith a copy of the IDS dated 17 April 2001, including copies of the references. Also included is a copy of the Certificate of Mailing under 37 CFR 1.10 and a copy of the Express Mail label under which the IDS was transmitted to the USPTO.

g. Renumbering Specification

Applicant acknowledges that Page 2A has been renumbered to Page 3 and that subsequent pages have been renumbered. Applicant wishes to thank the Examiner for making this correction.

h. Additional Art

Applicant has considered the additional art cited by the Examiner but not relied upon. It is believed that none of the additional art is more pertinent to the examination of the present application than that which has been addressed above.

i. Conclusion

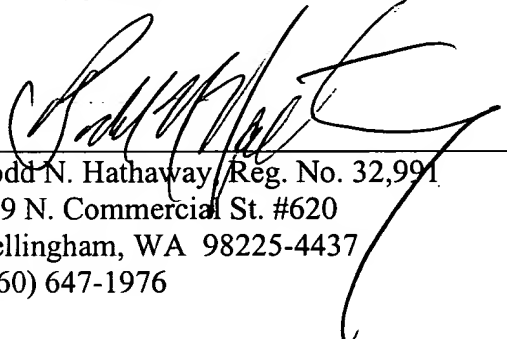
Applicant respectfully requests reconsideration of the present application in view of the amendments and remarks set forth herein. It is believed that all claims are now in condition for allowance. If there is any matter that can be expedited by consultation with Applicant's attorney, such would be welcome. Applicant's attorney can normally be reached at the telephone number given below.

Signed at Bellingham, County of Whatcom, State of Washington this 5th day of April 2002.

Respectfully submitted,

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